INVESTIGATIONS LEADING TO THE PRODUCTION USE OF THE COHERENT LIGHT ENLARGER

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Introduction

A development program for a coherent enlarger has resulted in an instrument which is capable of extremely high performance. This instrument basically substantiates certain phases of the theory of coherent imagery which were outlined in the initial proposal for the enlarger program[1]. However, during the course of this development program, a great deal has been learned of theoretical and practical value. We now recognize that the theory as previously outlined is inadequate in certain respects. Theoretical shortcomings are found particularly in two respects:

1. A modulation transfer function for coherent or partially coherent systems is not readily measurable by standard techniques, and even if it were obtained, this function by itself is not adequate to describe these systems.

2. Throughout the program, the theory of image reproduction has been based on macroscopic density in the object, and has ignored the role of grain in the object film as a factor in the photographic reproduction process.

The first of these considerations has greatly complicated testing the enlarger. Effective tests have been limited to practical comparisons of the enlarger with other instruments, and to deductive tests based on selected test targets. Adequate measures for evaluating coherent or partially coherent systems are not presently defined.

The importance of the second consideration, relating to grain in the object, has become evident from a number of interesting observations made during the course of the enlarger test program. It is clear that the influence of this effect in coherent or partially coherent imagery cannot be ignored.

This report constitutes a proposal by The Perkin-Elmer Corporation to conduct a theoretical and experimental study of (1) performance criteria, (2) methods of testing and evaluating photographic reproduction systems, and (3) the effects of object granularity in such systems. The study would provide recommendations relating to these subjects. The test study and the grain effect study are included in one proposal since they are closely interrelated and will involve the same experimental equipment to a large extent.

System Test and Evaluation

The inadequacy of conventional transfer function measurements for evaluating coherent and partially coherent systems is pointed out quite explicitly by Beran and Parrent[2] who stress the fact that coherent systems are linear in amplitude whereas incoherent systems are linear in intensity, and who also point out the dependence of the image on the character of the object in coherent transfer. The difficulties of attempting to measure a modulation transfer function have been demonstrated during the testing and evaluation of the enlarger.

On the positive side, work has been done by various investigators which might form the basis for suitable test methods. For example, Linfoot[3] offers three fairly simple "quality factors" for rating optical systems. These have been developed by O'Neill[4] into forms which may be simpler to derive from test data. The Linfoot criteria can be considered as one suggested starting point for the development of a simple practical test procedure. Other possible starting points undoubtedly exist and will be revealed during the initial phase of the proposed study.

We anticipate that the proposed investigation will result in a simple definitive test procedure which will yield valid and meaningful data for the type of systems considered. We also expect to be able to augment such quantitative data by tests of a more subjective nature based on the development of suitable test targets.

Grain Phenomena Investigation

Early in the enlarger test program, we noticed that the enlargements which were produced under coherent conditions presented a peculiarity in appearance not present in enlargements made on other instruments, or even by the same enlarger used non-coherently. The typical appearance under coherence is one of enhanced graininess, but cannot be due to resolution of individual object grains (which are several times too small and too high in spatial frequency to account for the appearance).

In spite of this phenomenon, typical comparative test photographs enlarged with coherent light appear to provide more information than counterparts made on a non-coherent enlarger. However, the visible graininess definitely lies in the spatial frequency region where interference with high frequency resolution would occur, particularly at low modulations.

We can say little at present about the origin of this peculiar graininess, as this is still conjectural. It is certain that any grain "noise" background will contain component frequencies much lower than that of the actual grain particles. Granularity spectra of many film emulsions have been measured, for example by Thiry[5] who shows that the spectra typically increase in amplitude with decreasing frequencies down to a few cycles per millimeter. To some extent this is probably due to clumping during development, which will result in lower aggregate frequencies.

The importance of average negative density on graininess is expounded in two recent papers[6,7]. The latter reference[7] also contains surprising photographs made by a system filtered to remove all macroscopic density detail of the original, depending only on the higher frequency grain detail acting as a carrier to transfer the image. Such experiments immediately bring into question our practice in coherent imagery of limiting the numerical aperture of the enlarger system to that required to accept the expected frequency of the detail in cycles per millimeter of the recorded image.

Apart from its function in the reproductive process, the subjective effect of graininess in the final image must be considered. Some illustrations contrived by Bela Julesz[8] indicate graphically the effect of a relatively small noise component in vitiating pattern recognition on a granular background. This work may in fact form a basis for the fabricating of a series of subjective test targets.

The importance of the grain investigation is not limited to systems having maximum coherence. It must be recognized that any enlarger which depends on nearly specular transmission possesses a high degree of lateral coherence. The typical grainy appearance has been noted[9] in a description of a more conventional type of enlarger, where apparently its significance is not recognized.

The importance of graininess in photographic reproduction is significant from other standpoints. R. C. Jones[10] recognizes an optimum density in terms of grain population for preserving information.

It is contemplated that in the course of the investigation, this phenomenon will be identified as to cause, and its effect on the detectivity and interpretation process evaluated.

Production Use of the Coherent Light Enlarger

The foregoing investigations, tests and evaluations are necessary prerequisites to practical production use of the coherent light enlarger. In this case, means will be explored for obtaining maximum benefit of the high instrumental performance under volume production conditions. This study is expected to result in recommended operating methods and techniques for the coherent light enlarger. Recommended modifications to the enlarger will be cited if they are found to be necessary in production use of the enlarger.

STATEMENT OF WORK

Perkin-Elmer will provide the necessary personnel, services and facilities to accomplish the following recommended tasks:

Task 1: Conduct studies to establish the criteria appropriate for describing the performance of the coherent photographic enlargement system.

Task 2: Conduct theoretical studies of test and evaluation methods for coherent, partially-coherent, and non-coherent photographic enlargers.

Task 3: Conduct theoretical studies of grain phenomena associated with the photographic enlarging process.

Task 4: Conduct an experimental program of performance tests to evaluate the coherent light enlarger according to the findings of Items 1, 2 and 3. These tests will use the coherent light enlarger as government furnished equipment.

Task 5: Conduct studies of optimum factors characterizing a coherent light enlarger for production use; evaluate the GFE coherent light enlarger.

Task 6: Deliver a final report of the findings which result from these studies; report will include recommendations for production use of the coherent light enlarger.

References

1. Proposal for Prototype Coherent Light Enlarger and Spatial Filter, Engineering Report 7354 (Perkin-Elmer Corp., Norwalk, Conn., 1963).
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6. B. E. Bayer, J.Opt.Soc.Am., 54:1485 (1964).
7. P. G. Roetling, J.Opt.Soc.Am., 55:67 (1965).
8. B. Julesz, Scientific American, February 1965, p.38
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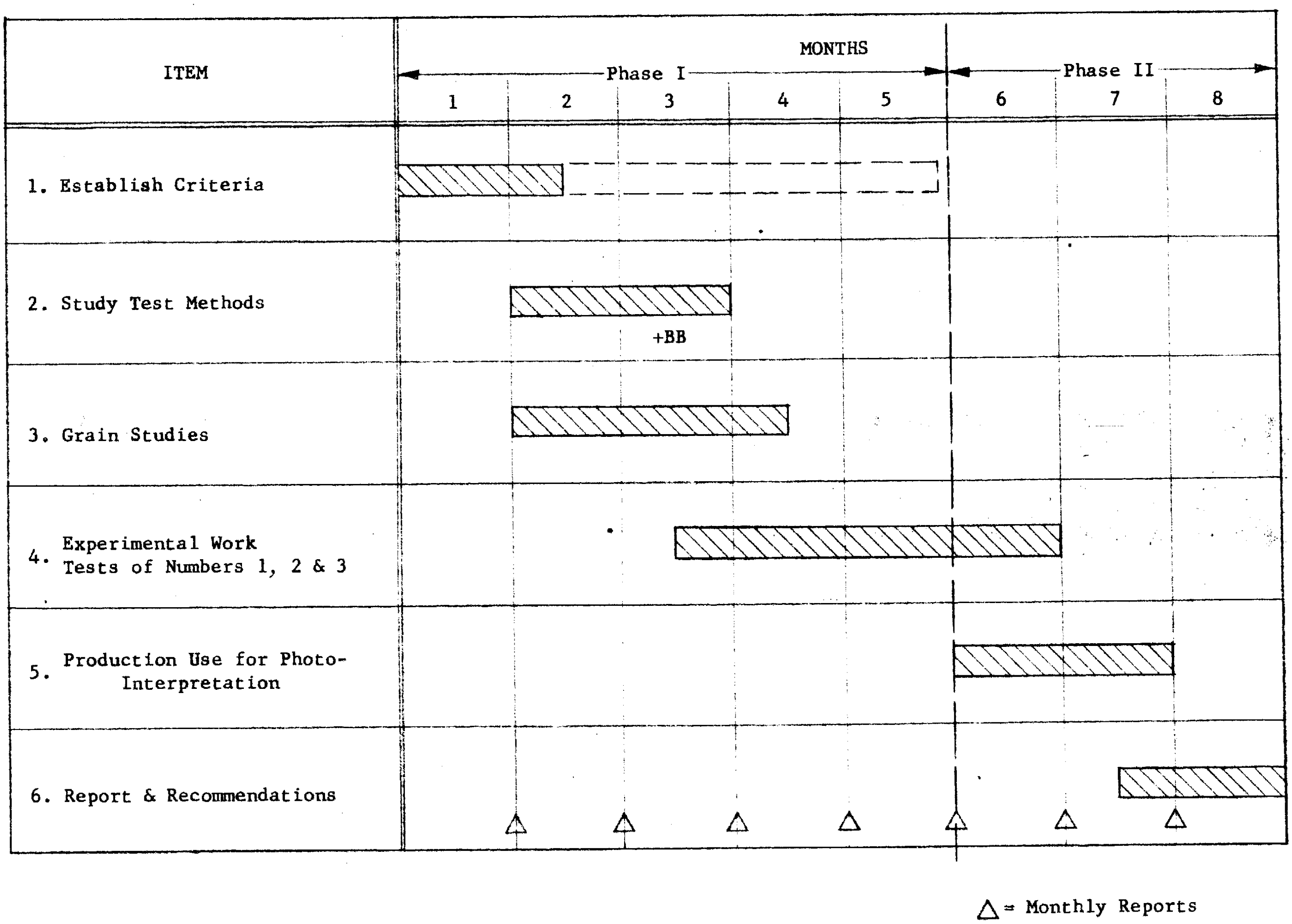
ITEM
MONTHS
Phase I
Phase II
1
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1. Establish Criteria
2. Study Test Methods
+BB
3. Grain Studies
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